THE USE OF ^{32}P AND ^{15}N TO ESTIMATE FERTILIZER EFFICIENCY IN OIL PALM

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ABSTRACT

THE USE OF ^{32}P AND ^{15}N TO ESTIMATE FERTILIZER EFFICIENCY IN OIL PALM. Oil palm has become an important commodity for Indonesia reaching an area of 2.6 million ha at the end of 1998. It is mostly cultivated in highly weathered acid soil usually Ultisols and Oxisols which are known for their low fertility, concerning the major nutrients like N and P. This study most conducted to search for the most active root-zone of oil palm and applied urea fertilizer at such soils to obtain high N-efficiency. Carrier free $KH_2{}^{32}PO_4$ solution was used to determine the active root-zone of oil palm by applying ^{32}P around the plant in twenty holes. After the most active root-zone have been determined, urea in one, two and three splits were respectively applied at this zone. To estimate N-fertilizer efficiency of urea labelled ^{15}N Ammonium Sulphate was used by adding them at the same amount of 16 g ^{15}N plant^{-1}. This study showed that the most active root-zone was found at a 1.5 m distance from the plant-stem and at 5 cm soil depth. For urea the highest N-efficiency was obtained from applying it at two splits. The use of ^{32}P was able to distinguish several root zones: 1.5 m – 2.5 m from the plant-stem at a 5 cm and 15 cm soil depth. Urea placed at the most active root-zone, which was at a 1.5 m distance from the plant-stem and at a 5 cm depth in one, two, and three splits respectively showed difference N-efficiency. The highest N-efficiency of urea was obtained when applying it in two splits at the most active root-zone.

Keywords : Oil palm, ^{32}P, ^{15}N, N-efficiency

INTRODUCTION

Recently oil palm has become an important commodity for Indonesia. At the end of 1998, oil palm area has reached 2.6 million ha. However, these areas are dominated by highly weathered acid soils usually Ultisols and Oxisols. These type of soils are well known for their low fertility especially concerning the major nutrients like N and P. Consequently, to obtain reasonable yields, N and P fertilization is undoubtedly needed.

Cost of fertilization for oil palm is quite high, taking 40 – 60 % of the maintenance cost. It is expected that fertilization with such high cost should be used as efficient as possible by the crops. To obtain high efficiency of fertilizers several practices could be implemented. These practices are e.g., the right dose, the right combination, the right formula, the right time and way of applications of the fertilizers [1]. The study done by SIAHAAN *et al.* [2], could add another important practice, which is namely the right placement of the fertilizers. The right placement of the fertilizer has a connection with the physiologically active roots of the crops. If the fertilizers are placed at the zones where the most active roots are found than this could help to increase the fertilizers use efficiency.

Previous work showed that by using ^{32}P, it was possible to determine the active root zones of tea and chinchona [3, 4]. The experience from previous work was used to do the same work for oil palm. After having estimated the active root zone of oil palm, the next step was to place N-fertilizer at the most active root zone to increase N-fertilizer use efficiency.

The work reported in this paper was the use of ^{32}P to determine the most active root zone and place N-fertilizer at this particular area to enhance N-fertilizer use efficiency studied by using ^{15}N in oil palm.

MATERIALS AND METHODS

Determination of active root zones

1. Plant material

Plants used were 8 years-old oil palm trees having an average height of 2.5 m, 25 cm stem diameter (1 m above soil surface), and 25 leaves. The plant distance is 9 m x 9 m.

2. ^{32}P application and placement

^{32}P was injected in a circle around the tree in 20 holes. The place of injection was 1.5 and 2.5 m from the tree stem and at a depth of 5 and 15 cm respectively (Fig.1), using 3 replicates, making the total use of 12 trees. ^{32}P was in the form of $KH_2{}^{32}PO_4$ carrier-free solution, with total activity of 343 mCi 1400 ml^{-1}. Each tree received 100 ml injected in 20 holes (5 ml $hole^{-1}$) with a total activity of 24.5 mCi. ^{32}P application was done at September 30, 1996.

3. Parameters observed

Parameters observed was the radioactivity content of leaf no 9 and 17 of each tree expressed in dpm (disintegration per minute). Both leaves were divided in 3 parts; upper, centre, and bottom (Fig.1). The leaves were harvested 2 and 4 weeks respectively after ^{32}P application. The data presented were from the last harvest. The radioactivity content of the samples (2 g) was counted using a Liquid Scintillation Analyser TRI-CARB 1000 TR, PACKARD.

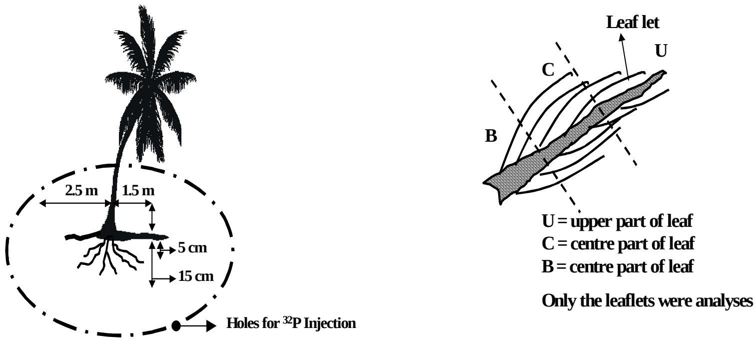

Figure. 1. Location of ^{32}P injection and leaf parts analysed for dpm.

Estimation of urea-N efficiency

1. Plant material

Oil palm trees used were the trees, which have been used for root determination 3 months later after the last ^{32}P harvest.

2. Treatments

The treatments conducted were shwon in Table 1

Table 1. Fertilizer treatment variation.

	1st application		2nd application		3rd application	
	urea	^{15}N-AS	urea	^{15}N-AS	urea	^{15}N-AS
	(g)					
N0	0	20	0	20	0	40
N1	1000	20	0	20	0	40
N3	500	20	500	20	0	40
N3	400	20	300	20	300	40

Remark : - Three replicates was done for each treatment
- - Atom excess of ^{15}N-Ammonium Sulphate (AS) = 9.754%

Based on the results showing different active root zone, the zone 1.5 m from the stem and 5 cm soil depth was chosen to test the efficiency of N-fertilizer usually urea. This zone was chosen due to that this zone has the highest root growth.

3. Parameters observed

Like in the experiment with ^{32}P, the 9 th and 17th leaves were used to determined the % a.e. of ^{15}N (percentage of atom excess). In this experiment the leaves were not divided in three parts. All the leaflets were used as samples. Based on the % a.e. of ^{15}N labelled Ammonium Sulphate, percentage-N derived from ^{15}N Ammonium Sulphate could be calculated. Having obtained the % N-dff^{15}N AS data, the partitioning of N, which was % N-dff^{15}N AS, % N-dff soil, and % N-dff urea could be done. The N-total percentage (% N-total) was determined by using the Kjeldahl method the percent atom excess was analysed by Emision Spectrometer type NOI-6PC. The calculation of % N-dff ^{15}N AS, % N-dff soil, % N-dff urea, is described below. From the Table 1 for the 9th leaf the % a.e. of N0 and N1 are 0.202 and 0.035 respectively. From these values the %N-dff^{15}N AS (N-derived from fertilizer ^{15}N AS), %N-dfs (N-derived from soil) and %N-dfu (N-derived from urea) could be determined as described by ZAPATA (5). N0 is the treatment where the oil palm trees received only 80 g ^{15}N-labelled AS, is equal to 16 g ^{15}N with a 9.754% a.e. and none urea. This treatment was applied to determined the A-value of the soil (A-soil) which is the N-soil available to plants and is calculated as follows:

$$\%\text{N-dff } ^{15}\text{NAS} = \frac{\%\text{a.e. of sample}}{\%\text{a.e. of } ^{15}\text{N-AS}} \times 100\%$$

$$= \frac{0.202}{9.754} \times 100\% = 2.07\%$$

The %N-soil = 100% - %N-dff^{15}N AS = 100 – 2.07 = 97.93

The fractional utilization is as follows:

$$\frac{2.07}{16^*} = \frac{97.93}{\text{A-soil}} \qquad \text{A soil} = 757 \text{ g N}$$

*16 = ^{15}N applied (g N tree-1)

N1 is the treatment where the oil palm trees receive 80 g ^{15}N-labelled AS (16 g ^{15}N-AS) + 1000 g urea.

$$\%\text{N-dff } ^{15}\text{N AS} = \frac{\%\text{a.e. of sample}}{\%\text{a.e. of } ^{15}\text{N-AS}} \times 100\%$$

$$= \frac{0.035}{9.754} \times 100\% = 0.36\%$$

The fractional utilization is as follows :

$$\frac{0.36}{16^*} = \frac{100 - 0.36}{\text{A (soil+urea)}} \qquad \text{A soil + urea} = 4428 \text{ g N}$$

*16 = ^{15}N applied (g N tree-1)
A soil (calculated from N0) = 757 g N
A urea (N-available from urea) = 4428 – 757 = 3671 g N.

The use of fractional for calculating each percentage derived from different sources resulted in

$$\frac{0.36\%}{16 \text{ g N}} = \frac{\%\text{N-soil}}{757 \text{ g N}} = \frac{\%\text{N-urea}}{3671 \text{ g N}}$$

$\%^{15}N = 0.36$
%N-soil = 17.03
%N-urea = 82.61

RESULTS AND DISCUSSION

Determination of active root zones

As shown by Fig.2, the upper part of the leaflets give the higher dpm values. This is true for both leaves namely the 9th and 17th leaf-but it was also shown that the 9th leaf gave higher dpm values than the 17th leaf. This is a common phenomenon where younger leaves will have higher P content suggesting including ^{32}P. The same trend was shown from a previous work showing young leaves of chinchona having a higher count per minute (cpm) values compared to older leaves [4]. In this work the leaves are numbered from top down, so the 9th leaf is younger than the 17th leaf.

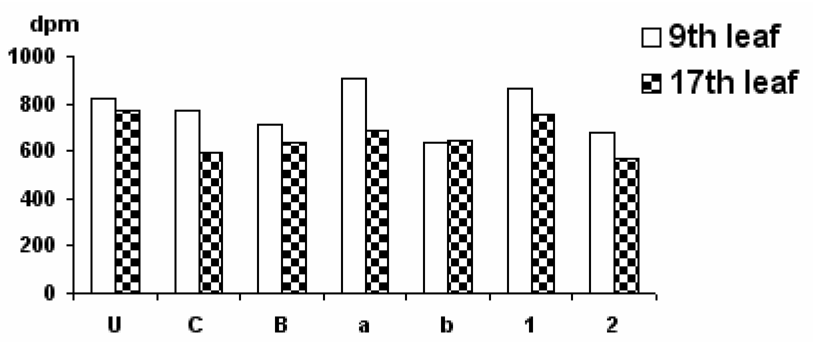

Figure 2. Dpm values in samples of oil palm leaves.

Root zone at a distance of 1.5 m from the stem shows higher dpm values compared to the root zone at 2.5 m. For the soil depth the higher dpm values were found for the 5 cm soil depth compared to the 10 cm soil depth. All these were shown clearly by both leaves (Fig.2). Based on the dpm values it could be concluded that the higher root active zone is located at a 1.5 m from the plant-stem and at a 5 cm soil depth, than the other placements. This finding could be explained by the application of the fertilizer given year by year for the oil palm crop in this area. Fertilizer N, P, K is applied in a circle approximately 1.5 m from the plant-stem and brood east at the soil surface.

The rates of fertilizers applied as 1 kg of urea, TSP and KCl per tree, twice a year. Apparently this way of application caused the roots of the plants to be concentrated around the zone of application. This could be the reason why the highest active root-zone was as has been obtained from this work.

Estimation of urea-N efficiency

In Table 2 the data of % N-to (percentage of total-N) and % a.e. are presented. The % N-to showed not much difference between the fertilizer treatments (N0, N1, N2, N3) for both leaves although a difference-test was not carried out. The % a.e. values were low due to the large volume of each tree but could still be detected.

Table 2. Total-N percentage and atom excess percentage in oil palm leaves

	D9		D17	
	% N-total	% atom excess	% N-total	% atom excess
N0	2.164	0.202	2.016	0.169
N1	2.147	0.035	1.540	0.092
N2	2.133	0.038	2.053	0.068
N3	2.014	0.095	1.895	0.085

All the values in Table 2 is an average 3 replicates

From Table 2 it could be observed that the % N a.e. values of treatment N0 (no urea applied) are all higher than the other treatments : N1, N2, N3, where urea was applied in different splits, at a rate of 1 kg urea tree^{-1}. Based on the % a.e. the values the partitioning of N in the plant sample could be carried out as presented in Fig 3.

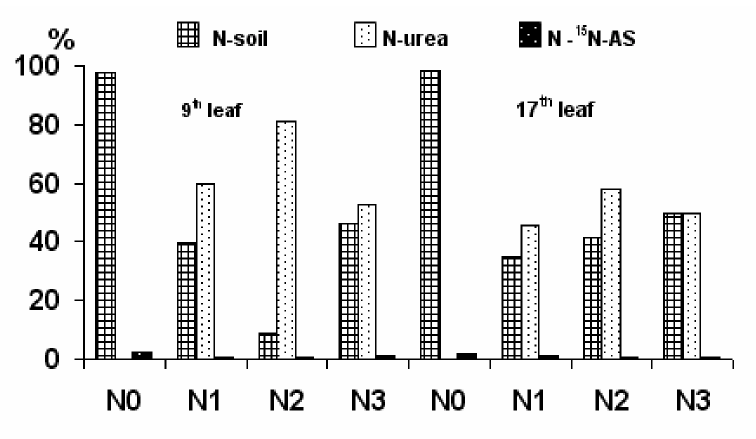

Figure 3. N-partitioning in samples of soil palm leaves.

Following the trend of % a.e., the % of ^{15}N-AS are also very small, but the % ^{15}N-AS values in the N0 treatment are also higher than the other treatments. In the same Figure it also shown that for all urea treatments: N1, N2, N3, the %N-urea is higher than the %N-soil except for the N3 in the 17th leaf. The highest %N-urea for both leaves: 9th and 17th, are from the N_2-urea treatment, where urea at a rate of 1 kg tree^{-1} was applied in 2 splits. In carrying out this work it was expected that large quantities of N-soil was expected to be higher that the %N-urea. This expectation was based on the fact that the soil in this area at least have received around 7 year of fertilization of urea, and this N-urea from previous fertilization was expected to become N-soil in this work, but the reversed was obtained. Based on this it could be suggested that the oil-palm crop are more in favour of N readily available namely, N-urea.

As mentioned before all the plants receiving N1, N2, N3 got the same urea rate, 1 kg urea tree^{-1}, but at different split-application. Based on the same rate of urea applied it is suggested that the higher % N-urea would mean higher N-urea uptake. From the data it could be estimated that the highest N-urea use efficiency will be obtained if urea is applied in two splits at place at the most active root zone.

Further work is still needed whether the pattern of root growth will change with age of the crop.

CONCLUSIONS

The use of ^{32}P was able to distinguish several root zones: 1.5 m – 2.5 m from the plant-stem at a 5 cm and 15 cm soil depth. In this work the most active root-zone was at a 1.5 m distance from the plant-stem and at 5 cm soil depth. At this most active root-zone urea was pleased to enhance its efficiency. Urea was applied in different splits, namely 1 kg urea tree^{-1}: in one split, two splits and three splits. Data obtained showed that by using ^{15}N it was able to estimate the highest N-urea efficiency. Urea placed at the most active root zone in two splits gave the highest % N-urea. With this data it could be estimated that the highest % N-urea will gave the highest N-urea efficiency.

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